Static interaction of Skyrmions in magnetic thin-film circuits patterned by anisotropy undulations

Osaka Univ.[1], CSRN-Osaka[2], KRISS[3]
○C. Liu[1], Y. Jibiki[1], S. Miki[1], J. Cho[3], E. Tamura[1], M. Goto[1,2], H. Nomura[1,2], Y. Suzuki[1,2], R. Nakatani[1]
E-mail: chaozhe.liu@mat.eng.osaka-u.ac.jp

Previously, we have shown experimentally that skyrmions can be confined in a canal drawn by magnetic anisotropy undulations [1]. In this study, we estimate the skyrmion-skyrmion and skyrmion-wall interactions that govern the motion of skyrmions in the canal.

First, we observe the 1-dimensional motion of skyrmions in the straight canal with a constant anisotropy gradient k_g, so that the anisotropy is given by $K = K_0 + k_g x$, by means of micromagnetism simulator MuMax3. From the obtained velocity $\dot{X}$ we can estimate the force F_{ani} by the anisotropy gradient (Fig. a) as

$$F_{ani}(k_g) = \alpha D \dot{X}(k_g)$$

where α is the damping constant, D is the dissipation dyadic [2].

Second, we can determine the skyrmion-skyrmion and skyrmion-wall interactions by means of forces in balance in which the skyrmion-skyrmion and skyrmion-wall distances d are $F_{ani}(k_g)$-dependent (Fig. b and c). For the skyrmion-skyrmion case, we choose a V-slope anisotropy gradient, while a single-sided gradient is used in the skyrmion-wall case. Since the dissipation dyadic D is dependent on the size and profile of skyrmions, the interactions depend also on those of skyrmions.

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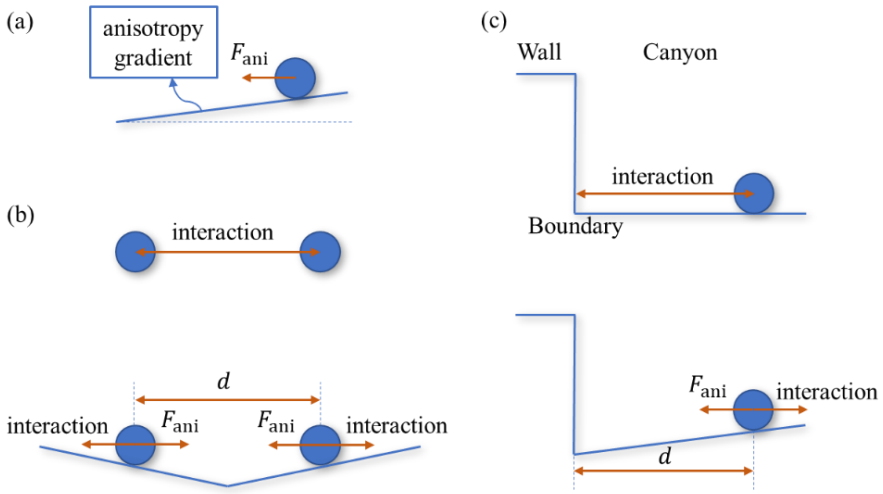

Fig. (a) The force caused by the anisotropy gradient. (b) Skyrmion-skyrmion case, the interaction between two skyrmions equals to the anisotropy gradient force with a V-slope gradient.
(c) Skyrmion-wall case, the interaction equals to the anisotropy gradient force.

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